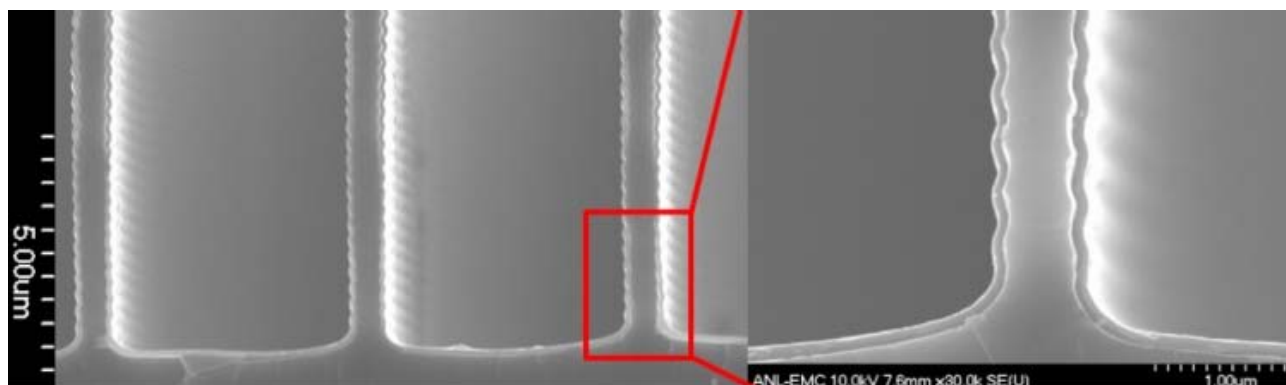


AROUND THE WORLD

A conformal approach to cavity coating

Argonne scientists give metals a healthy superconducting coat, one atomic layer at a time.

by Leah Hesla



Argonne researchers are working to coat accelerator cavities with perfectly uniform atomic layers of niobium. The thin film technology could help slash production and operation costs in particle accelerator programmes while boosting accelerator performance.

FEATURE

from CERN: LHC sets world record beam intensity



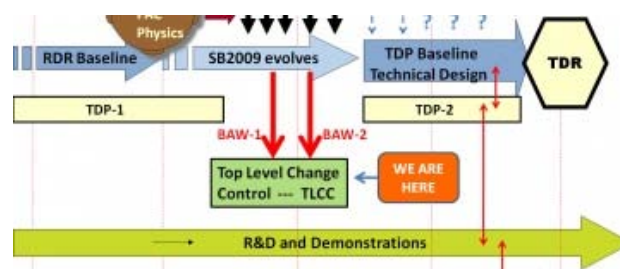
Geneva, 22 April 2011. Around midnight this night CERN's Large Hadron Collider set a new world record for beam intensity at a hadron collider when it collided beams with a luminosity of $4.67 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$. This exceeds the previous world record of $4.024 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$, which was set by the US Fermi National Accelerator Laboratory's Tevatron collider in 2010, and marks an important milestone in LHC commissioning. Read the [CERN press release](#).

DIRECTOR'S CORNER

The new baseline and the next steps

Today's issue features a Director's Corner by Ewan Paterson, member of the Global Design Effort Executive Committee.

by Ewan Paterson



The new ILC baseline shows the way to designing a linear collider that maintains original performance while using cost-saving alternatives.

IMAGE OF THE WEEK



Michel Davier receives 2010 André Lagarrigue Prize

[Michel Davier receives the 2010 André Lagarrigue Prize](#) from Martial Ducloy, president of the French Physical Society, on 26 April at the Linear Accelerator Laboratory in Orsay, France.

IN THE NEWS

from **BBC News**

26 April 2011

[Alpha Magnetic Spectrometer to go on Endeavour shuttle](#)

It is the most complex space physics experiment ever built, and it will launch on shuttle Endeavour this week.

from **Ars Technica**

25 April 2011

[World's biggest antimatter nucleus produced at Brookhaven](#)

The RHIC is back in the news today, as one of its detectors has found evidence of the production of anti-helium-4 nuclei. The rates at which these particles were produced, however, suggests that we won't be seeing anti-nuclei of any greater complexity anytime soon.

from **Guardian**

24 April 2011

[US scientists get glimpse of antihelium](#)

Scientists in the US produced a clutch of antihelium particles, the antimatter equivalents of the helium nucleus, after smashing gold ions together nearly 1bn times at close to the speed of light.

from **Bay News 9**

21 April 2011

[Unlocking secrets of the universe part of Endeavour's last mission](#)

It's fitting shuttle Endeavour's final mission is once again to the International Space Station, as its cargo includes a tool to find potential origins of the universe.

from **KPNW radio (Eugene)**

22 March 2011

[Interview with Brian Foster \(mp3, 6.7 MB\)](#)

Listen to an interview with Brian Foster that aired on 22 March on KPNW, during ALCPG11 in Eugene, Oregon, US, and learn about particle physics, extra dimensions, linear colliders and particle slams.

ANNOUNCEMENTS

AMS detector heads for International Space Station

On 29 April 2011, the [Alpha Magnetic Spectrometer](#) will take off for the International Space Station on board Space Shuttle Endeavour. *ILC NewsLine* will bring you more on this special event in a future issue.

Read [CERN's press release](#).

SRF2011 registration open

SRF2011, the largest international conference on superconducting radio frequency technology, will be held in Chicago, Illinois, US from 25-29 July 2011. The conference is a meeting of scientists, engineers, students and industrial partners on the latest developments in SRF for particle accelerators. Early registration ends on 1 May.

[Register](#) – Visit the [SRF2011 website](#)

BLOGLINE

7 March 2011

CERN

[A spring clean for the LHC](#)

CALENDAR

UPCOMING EVENTS

[Linear Collider Power Distribution and Pulsing workshop](#)

LAL, Orsay, France

09- 10 May 2011

[ILD Workshop 2011](#)

location changed to:

LAL, Orsay, France

23- 25 May 2011

[Second Workshop on linac operation with long bunch trains](#)

DESY, Hamburg, Germany

06- 08 June 2011

[Technology and Instrumentation in Particle Physics 2011](#)

[\(TIPP 2011\)](#)

Chicago, IL

09- 14 June 2011

UPCOMING SCHOOLS

[École IN2P3 - Pays Méditerranéens des Accélérateurs de Particules](#)

Gammarth-Tunis, Tunisia

09- 14 May 2011

[USPAS sponsored by Stony Brook University](#)

Melville, New York

13- 24 June 2011

[View complete calendar](#)

PREPRINTS

ARXIV PREPRINTS

[1104.4547](#)

Performance studies of a pixel tracker in the Silicon Detector (SiD) concept for a future linear collider

[1104.4067](#)

Calculating contracted tensor Feynman integrals

AROUND THE WORLD

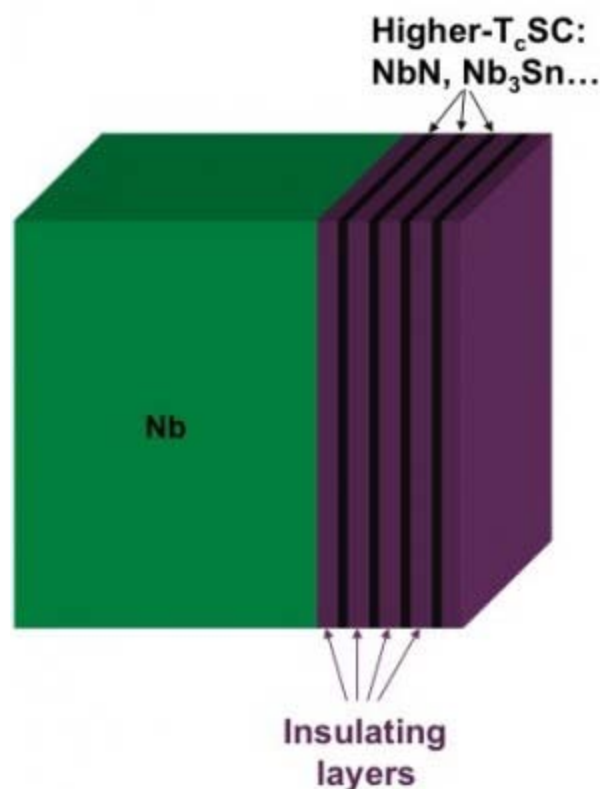
A conformal approach to cavity coating

Argonne scientists give metals a healthy superconducting coat, one atomic layer at a time.

Leah Hesla | 28 April 2011

A necklace of cheap metal with gold-flaked paint may look like solid gold finery, but eventually, the paint will peel, revealing a worthless trinket beneath.

But an accelerator cavity of inexpensive metal with a nice niobium coat, though less expensive than a solid niobium structure, could actually hold more value for a particle collider.



For multi-layer superconducting films, a bulk, one-micrometre layer of niobium is further coated with niobium-compound, nanometre-scale thin films. For accelerator cavities, this combination of superconducting layers could be applied to an aluminium or copper cavity and achieve acceptable magnetic fields. Image courtesy of Thomas Proslie.

Scientists at Argonne National Laboratory in the US are developing a method that uses atomic superconducting layers to evenly cover, like the perfect coat of paint, the insides of cavities. Since electric current flows only through the cavity wall's innermost hundred nanometres, thin niobium-compound films could provide an alternative to pricier, solid niobium cavities.

"We're trying both to make better superconductors and to make them more cheaply," said James Norem, accelerator physicist in Argonne's High Energy Physics Division.

Using atomic layer deposition (ALD), as the method is called, scientists line bulk metals with nanometres-thin superconducting films. In one cavity model, a copper or aluminium body would support a micrometre-thick niobium layer (an amount still considered to be in the bulk range). Niobium-compound thin films are grown over it.

Realising this model could save money on several fronts. For a project like the ILC, the savings could range in the hundreds of millions of dollars.

One reason is that aluminium and copper are cheaper than niobium. Also, cavities would not have to be kept as cold as 2 kelvin (the current target temperature for niobium cavities) to superconduct effectively, cutting refrigeration costs; the operating temperature depends on the niobium compound used. Films also eliminate the need for the usual extensive

surface treatment of niobium cavities. And because niobium compound-coated cavities can achieve comparable or higher gradients than solid niobium ones, an accelerator would require far fewer of them.

But achieving those gradients depends on growing perfect, uniform layers. Researchers believe ALD can make that

happen for accelerators.

"We've grown by far the best superconducting film ever with this technique," said Argonne's Thomas Proslier, who is leading the laboratory's effort on ALD for cavity coating. So far Argonne researchers have tested the technique on various flat surfaces of aluminium, copper, niobium (niobium-compound films can enhance already-superconducting metals) and sapphire.

In one test, Proslier's team was able to grow a niobium nitride thin film that could superconduct at 14.5 kelvin, a temperature almost two-thirds higher than pure niobium's critical temperature of 9 K. They grew it on a flat substrate.

Coating flat surfaces is one thing. Evenly covering the undulating insides of an accelerator cavity is another beast altogether.

"You have to homogeneously coat the whole inside of the cavity, so the coating method can't depend on line of sight," Proslier said. "The strength of this technique is that it can coat arbitrarily complex-shaped objects."

With ALD, thin films are formed from gases that react with the substrate metal in a way that its surface becomes saturated with the gaseous atoms. As many atoms that can be attracted to the metal will be. Once they are, there's no room for any more to alight.

"Even if you wanted to, you couldn't make more than one atomic layer at a time," Proslier said.

The process ensures that only a single, superconducting stratum is deposited, one that settles as uniformly on curves and in crevices as it does on flat planes. As scientists like to say, the layer is conformal.

Different combinations of gases are used to build up the atomic layers, both superconducting and insulating, to get the desired multi-layer combination, which ends up being about 300 nanometres thick.

"The theory says that if you have a sandwich of superconducting and insulating layers, then you can get to higher fields than you would otherwise," Norem said.

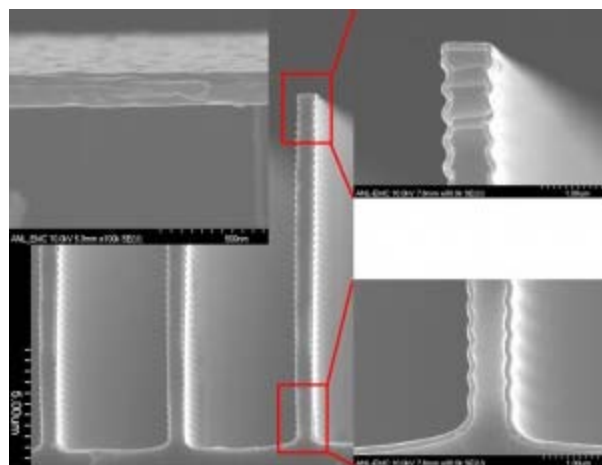
To optimise the multi-layer structure, they examine the various gases' chemical compositions. They also look at the resulting layers' crystallographic structure, superconducting properties, critical temperatures, densities and thicknesses.

"Right now we're trying to grow the multi-layer with as good as properties as we can get out of it," Proslier said. "We do everything we can to match the layers in the best ways possible."

Alex Gurevich, a condensed matter physicist now at Old Dominion University in Virginia, developed the theoretical basis for the behavior of superconducting multi-layers. Michael Pellin, an Argonne Distinguished Fellow and former Materials Science Division director, along with Norem and Proslier, saw that multi-layer thin films could be applied to accelerator cavities.

The Argonne team has been researching the technique for cavities with funding from the Department of Energy since 2009.

By this summer, Argonne researchers hope to complete ALD tests on single-cell niobium cavities. From there, they will move on to copper cavities and other higher-critical temperature materials.



Atomic layer deposition results in a conformal thickness of material. The layer evenly and uniformly coats any surface geometry. Image courtesy of Thomas Proslier.

“We’ve been optimising niobium cavities for 20 years,” Norem said. “Now we’re starting to work with materials that are potentially superior.”

[ARGONNE](#) | [ATOMIC LAYER DEPOSITION](#) | [CAVITY](#) | [CAVITY SURFACE](#) | [NIOBIUM](#) | [THIN FILMS](#)

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LHC sets world record beam intensity

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Geneva, 22 April 2011. Around midnight this night CERN¹'s Large Hadron Collider set a new world record for beam intensity at a hadron collider when it collided beams with a luminosity of $4.67 \times 10^{32} \text{cm}^{-2} \text{s}^{-1}$. This exceeds the previous world record of $4.024 \times 10^{32} \text{cm}^{-2} \text{s}^{-1}$, which was set by the US Fermi National Accelerator Laboratory's Tevatron collider in 2010, and marks an important milestone in LHC commissioning.

"Beam intensity is key to the success of the LHC, so this is a very important step," said CERN Director General Rolf Heuer. *"Higher intensity means more data, and more data means greater discovery potential."*

Luminosity gives a measure of how many collisions are happening in a particle accelerator: the higher the luminosity, the more particles are likely to collide. When looking for rare processes, this is important. Higgs particles, for example, will be produced very rarely if they exist at all, so for a conclusive discovery or refutation of their existence, a large amount of data is required.

The current LHC run is scheduled to continue to the end of 2012. That will give the experiments time to collect enough data to fully explore the energy range accessible with 3.5 TeV per beam collisions for new physics before preparing the LHC for higher energy running. By the end of the current running period, for example, we should know whether the Higgs boson exists or not.

"There's a great deal of excitement at CERN today," said CERN's Director for Research and Scientific Computing, Sergio Bertolucci, *"and a tangible feeling that we're on the threshold of new discovery."*

After two weeks of preparing the LHC for this new level of beam intensity, the machine is now moving in to a phase of continuous physics running scheduled to last until the end of the year. There will then be a short technical stop, before physics running resumes for 2012.

Contact

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1. CERN, the European Organization for Nuclear Research, is the world's leading laboratory for particle physics. It has its headquarters in Geneva. At present, its Member States are Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom. India, Israel, Japan, the Russian Federation, the United States of America, Turkey, the European Commission and UNESCO have Observer status.

DIRECTOR'S CORNER

The new baseline and the next steps

Today's issue features a Director's Corner by Ewan Paterson, member of the Global Design Effort Executive Committee.

Ewan Paterson | 28 April 2011

In an opening plenary session at ALCPG11 in Eugene, Oregon, I summarised the history and status of the process towards a new baseline for the design of the ILC. I present only an overview here.

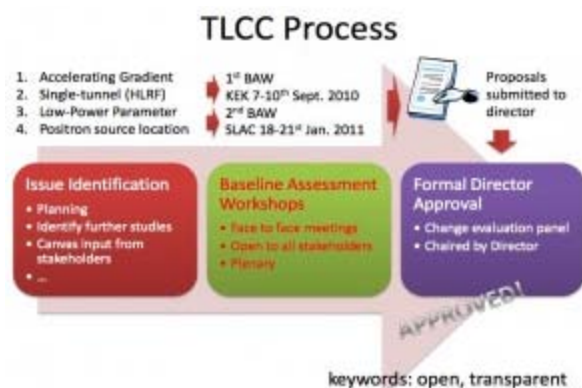


Figure 1. The Top Level Change Control process.

The year-long Top Level Change Control (TLCC) process was completed just in time for the Eugene meeting and is shown in Figure 1, along with where this fits into the present ILC project design schedule (Figure 2).

This new baseline is the starting point for the Technical Design Phase 2 (TDP2), which culminates in the updated *Technical Design Report (TDR)* by the end of calendar year 2012. This is a major milestone in the ILC/Global Design Effort schedule, though it is expected that technical R&D and systems demonstrations will continue well beyond this date.

There were four major topics or themes in the development of the new baseline: technology choice, simplification of civil design, beam parameters and systems design choices. The common threads were performance and cost containment. These have been extensively studied over the past 15 months, reviewed in baseline assessment workshops and formally approved by a change evaluation panel chaired by the director. Even after all of this work, the new design needs detailing and integration; this work began at the Eugene meeting. Over the next twelve months there will be system-by-system specialised workshops to finalise and document the details of an updated design for the TDR, which will include updated cost estimates.

In the area of technology choices it was agreed that the average accelerating gradient for the installed superconducting cavities would remain at 31.5 megavolts per metre as in the RDR, but also that a range of gradient would be accepted at the level of $\pm 20\%$. This will enable realistic studies of mass production models and costs and the optimisation of the radiofrequency (RF) power systems to efficiently match this spread in gradient in realistic operating scenarios.

For the civil engineering baseline, a single tunnel design has been adopted for the linacs by removing the support equipment tunnel. This change is supported by the development of one or both of the new radiofrequency

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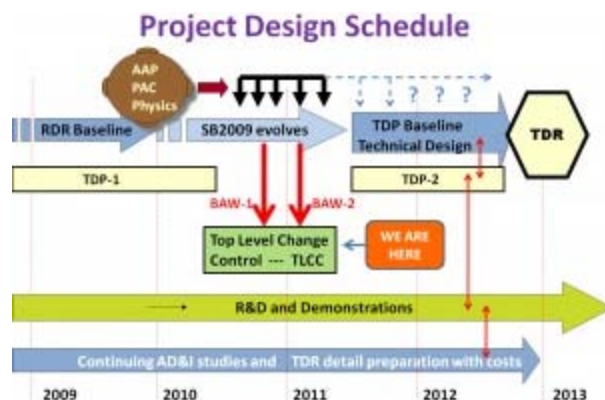


Figure 2. The current ILC project design schedule

powering schemes, the distributed RF system and/or the klystron cluster scheme. The linac housings now amount to one-third instead of two-thirds of the underground tunnels and this design approach can be adapted to almost any site.

A major impact on cost containment (equal to five to six percent of the total project cost) has been achieved by adopting a beam parameter set with half the number of bunches in each bunch train. This reduces the beam power and all the costs associated with providing it. It also enables using damping rings for half the circumference, which amounts to 3.2 kilometres in contrast with 6.4 km. The luminosity is recovered to the previous values with stronger focusing in the final focus, which means tighter beam-beam alignment tolerances and therefore some increase in risk. Many systems that are difficult to later upgrade, such as high-power beam dumps, continue to be designed for handling full power, defined as the power at one-teraelectronvolt (TeV) centre-of-mass energy. The damping ring tunnel will be sized to allow the possible future installation of a second positron ring where, with two 3.2-km rings, one can accommodate the original longer bunch train while maintaining the same spacing between bunches. This allows for possible luminosity upgrade paths without major civil construction or a luminosity and energy upgrade to 1 TeV with longer linacs. This continues to be part of the site specifications. An energy upgrade scenario from 0.5 to 1 TeV will be part of the TDP2 studies and the *Technical Design Report*.

The largest system design changes are associated with the move of the positron source systems from mid-linac (RDR design) to the end of the linac, overlapping and sharing tunnels with part of the beam delivery system. This change reduces the overall tunnel length required and simplifies the design and operation of the linac system itself. However one must still address the problem of maintaining a constant yield of positrons over a large range of final operating energy. With an undulator-based positron source, which would enable the production of polarised positrons, the positron flux is a function of both the intensity and the energy of the electron drive beam. We desire a final positron charge per bunch (that is, the charge per bunch at the interaction point) equal to that of the electron beam. To achieve this, we have adopted a solution for operating centre-of-mass energies less than 250 GeV, which differs from that in the reference design. That is, at the lower energies of less than 150 GeV per beam, we will operate the electron linac and injector systems at ten hertz instead of five, with half of the pulses producing positrons and half going to the interaction region. In this mode of operation the damping rings are required to have twice the damping rate. This is achieved using an increased number of wiggler magnets in the rings and with a commensurate increase in RF power supplied to the beam.

As magnet technology continues to advance, shorter-period, higher-strength undulators may become available and the optimisation of positron production for all energies, from those attained at the Large Electron-Positron Collider (CERN's former collider) on up to one TeV, may be done more simply by variations in the length and strength of these components.

Regardless, we have a new baseline from which to develop the TDR for an ILC that is ready to attack, over a broad energy range, the new physics that we believe will be uncovered by the LHC by the end of 2012.

[ALCPG11](#) | [BASELINE](#) | [ILC BASELINE](#) | [TECHNICAL DESIGN PHASE](#) | [TOP LEVEL CHANGE CONTROL](#)

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